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CIRCUMPLANETARY EXPLORATION OF ATMOSPHERES

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CIRCUMPLANETARY EXPLORATION OF ATMOSPHERES

(Exploration circumplanétaire des atmosphères)

(Czechoslovakia)

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PRAGUE

The first steps toward exploration of planets by means of spacecrafts are likely to be made in the course of their passage very near the planet, or even during the spaceship's temporary "satellization". Investigation of low atmospheric layers could then be envisaged by observing star occultations by the planet, expected to be more frequent than the similar phenomena observed from the Earth.

We shall present in the following the essential aspects of these phenomena's theory, broadly based on that of Earth's artificial satellite eclipse from the Earth [1, 2]. The theory could be considerably simplified, for the accessible parts of Venus' and Mars' atmospheres — the first to be taken into consideration — are relatively little dense. It should be then sufficient to photometer aboard the spaceship a star during its occultation by the planet, thus deriving the optical properties of the planetary atmosphere. Applied to the Earth, this method ends in the peripheral layers of the planetary atmosphere, while its application aboard the spaceship permits the reaching of the ground level.

The general transmission factor as a function of the luminous ray

passing at a minimum altitude h_1 (Fig. 1) will be given by the expression

$$T = \frac{10^{-AM}}{1 - (a + h) \cos \frac{d\omega}{dh_1}} \quad (1)$$

where M is the mass of air cut across by the ray, A is the absorption coefficient, a is the planet's radius, h is the altitude of the spaceship, ω is the total deviation of the ray, and the angle ψ (Fig. 1) is given by the formula

$$\sin \psi = \frac{a + h_1}{a + h} \quad (2)$$

In the exponential atmosphere of low density ρ , where

$$\rho = \rho_0 \exp - \frac{h}{H} \quad (3)$$

we shall have

$$\begin{aligned} \omega &= \rho_0 \exp - \frac{h_1}{H} \quad 2\pi\beta a = \omega_0 \exp - \frac{h_1}{H} \\ c &= 293 \cdot 10^{-6}, \quad \frac{d\omega}{dh_1} = - \frac{\omega}{H} \quad M = H \frac{\omega}{c} \end{aligned} \quad (4)$$

where H is the altitude scale.

Finally, the spaceships' position must be determined by the angle r

$$r = \psi - \omega \quad (5)$$

Then, knowing the optical parameters of the atmosphere, it is easy to compute the occultation's photometrical curve with the aid of these formulas.

In order to show the scope and efficiency of this method, we shall give here numerical examples relative to Venus and Mars, by assuming the following parameters:

	VENUS	MARS
Distance of the satellite $a + h$	18,300 km	13,200 km
$(a + h) \cos \psi$	17,500	12,430
Scales of height H	6	17
Total deviation ω_0	1'	2.76'
Absorption coefficient A	0.00575	0.00575 km

The total deviation ω_0 is variable for the transparency level on Venus and for the ground on Mars.

The respective photometrical curves are plotted in Fig.2 and 3, i.e. the logarithm of the occulted star's intensity as a function of the angle r , or of the time Δt , the satellite's orbit being assumed as circular.

The circumplanetary exploration is also adapted to the study of the dust layer, whose existence in the Mars' atmosphere is assumed. In the following, we shall adopt a simple model of the homogenous layer from the ground till the altitude $h_2 = 50$ km, with the optical density at zenith being $B = 0.03$. The optical density along the horizontal trajectory passing to the minimum altitude h_1 will be given by

$$B(h_1) = 2B \sqrt{\frac{2a}{h_2}} \sqrt{1 - \frac{h_1}{h_2}} \quad (6)$$

The results are also given in the Fig.3. It may be seen that the presence of the dust layer, of which the parameters correspond roughly to the violet layer on Mars [3] modify considerably the pattern of the

occultation.

The layer could also be revealed by the diffusion, when the satellite will be in the neighborhood of the limit of the solar shade. The layer to Sun luminance ratio is given by [4]

$$\frac{b}{b_0} = 1.2 \cdot 10^{-5} B(h_1) \quad (7)$$

For a ray passing at the altitude $h_1 = 40$ km, where the influence of the pure atmosphere already is negligible, the luminance will be $b = 0.5$ cd/cm, thus very clearly visible in daytime.

**** E N D ****

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Translated by ANDRE L. BRICHANT

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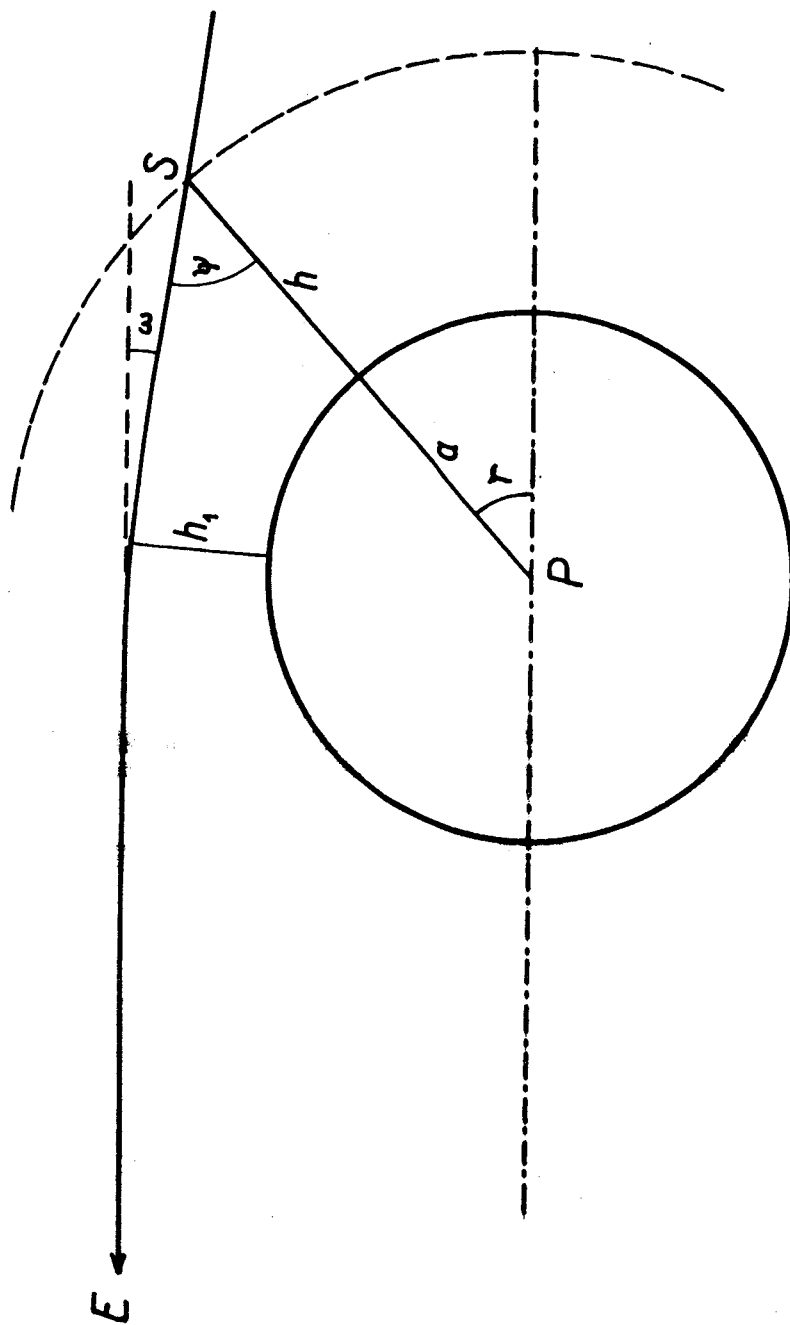


Fig. 1. Occultation of the star E observed from the satellite S in the course of its revolution around the planet P .

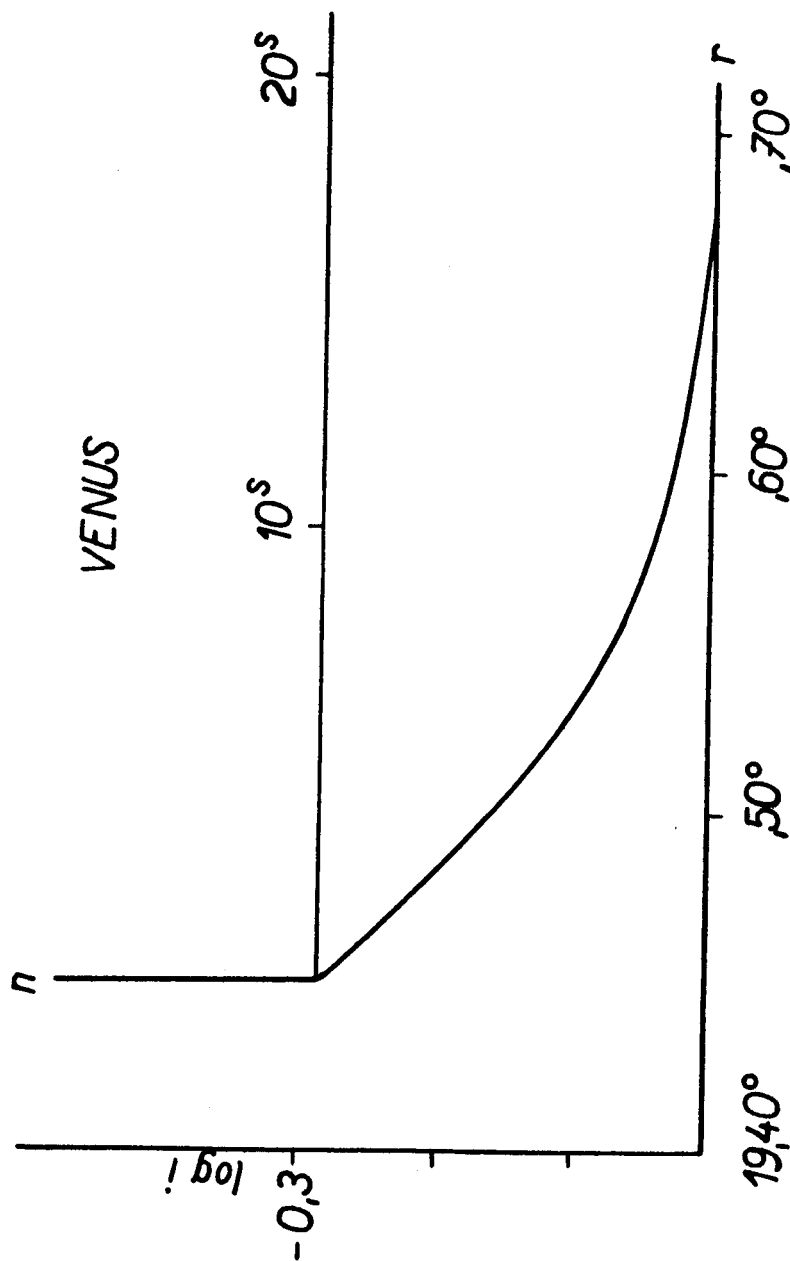


Fig. 2. Light curve of Venus' occultation, as a function of the angle r and of the time, n being the cloud level.

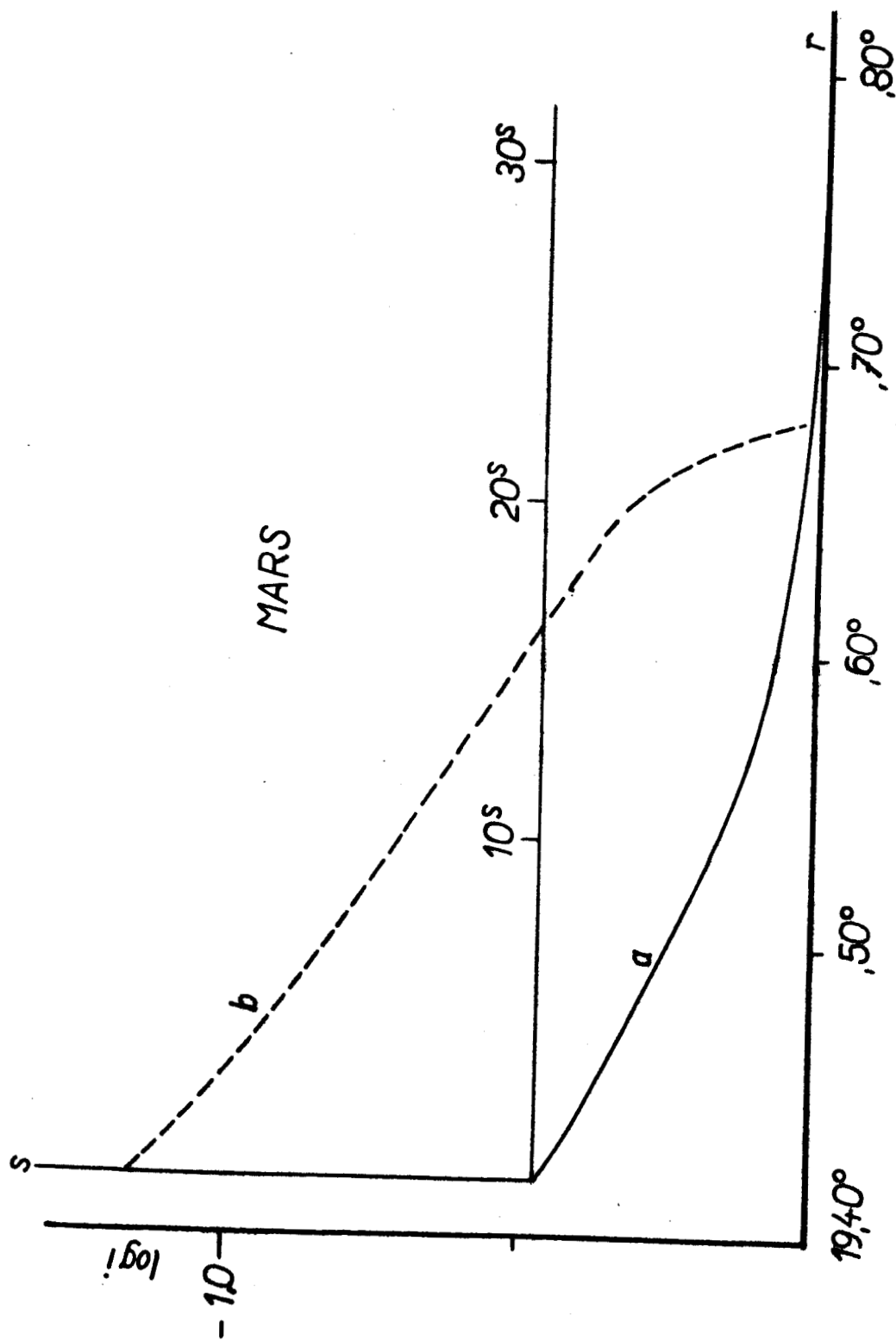


Fig.3. Light curve of Mars occultation, as a function of the angle r and of time, s being the ground level, a — the curve relative to the pure atmosphere, b — the curve a + the dust layer.